

HAS THE UNIVERSE A HONEYCOMB STRUCTURE?

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Recent analysis of the distribution of clusters of galaxies is reviewed. Clusters of galaxies located in rich superclusters form a quasiregular lattice similar in structure to honeycombs. The power spectrum of clusters of galaxies has a sharp peak at wavelength $\lambda_0 = 120 h^{-1}$ Mpc corresponding to the lattice step. The peak in the spectrum may be due to processes during the inflationary stage of the structure evolution.

1 Introduction

According to the current paradigm of the large-scale structure of the Universe galaxies and clusters of galaxies are concentrated to elongated filamentary chains and the space between filaments is void of galaxies. Such distribution resembles cells¹; examples are the Northern Local Void surrounded by the Local, Coma, and Hercules superclusters, and the Bootes void located between the Hercules and Bootes supercluster².

Superclusters and voids form a continuous network of alternating high- and low-density regions³. They are formed by density waves of wavelength corresponding to the scale of the supercluster-void network. It is believed that density waves have a Gaussian distribution, thus high- and low-density regions should be randomly distributed. It was therefore a great surprise when Broadhurst *et al.*⁴ found that the distribution of high-density regions in a small area around the northern and southern Galactic pole is fairly regular: high- and low-density alternate with rather constant step of $128 h^{-1}$ Mpc. The regularity is so far well established only in the direction of Galactic polar caps, in other directions the regularity is much less pronounced. In order to find the degree of regularity of the supercluster-void network 3-dimensional data of the distribution of high-density regions are needed. For this purpose Abell-ACO clusters of galaxies⁵ can be used, as they form the largest and deepest sample of astronomical objects covering the whole celestial sphere outside the Milky Way zone of avoidance.

2 Distribution of clusters of galaxies

The distribution of clusters of galaxies located in very rich superclusters with at least 8 member-clusters is shown in Figure 1³. We see a rather regular network of superclusters and voids. High-density regions are separated from each other by a rather constant intervals of $\approx 120 h^{-1}$ Mpc. Such quasiregular distribution resembles honeycombs or 3D chessboard⁶.

The correlation function of quasiregularly located sample of clusters of galaxies should have periodic maxima and minima which correspond to mutual distances of high- and low-density regions. Such a phenomenon is actually observed⁷. The power spectrum of clusters of galaxies has a peak on wavelength $\lambda_0 = 120 h^{-1}$ Mpc which corresponds to the size of the step of the supercluster-void network⁸ (see

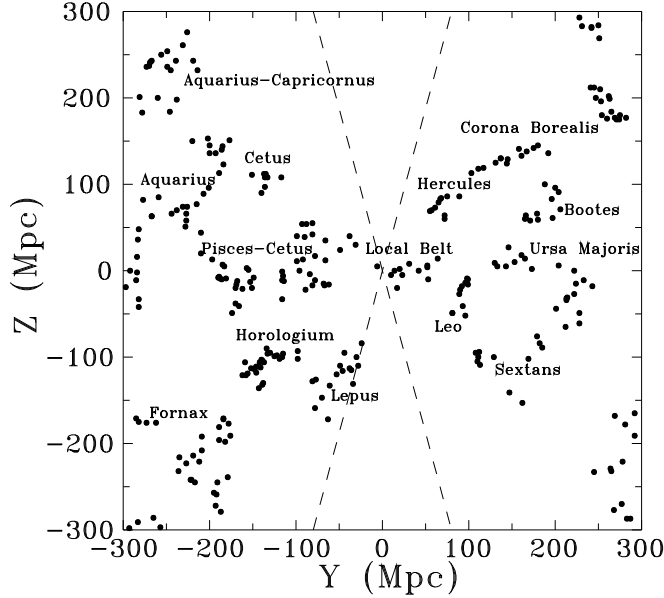


Figure 1: Distribution of clusters in high-density regions in supergalactic coordinates. Only clusters in superclusters with at least 8 members are plotted. The supergalactic $Y = 0$ plane coincides almost exactly with the galactic equatorial plane.

Figure 2). On short wavelengths the spectrum can be approximated by a power law with index $n = -1.8$. On long wavelengths the spectrum is compatible with the Harrison-Zeldovich spectrum with power index $n = 1$.

This unusual form of the power spectrum raises the question: Is such a peaked power spectrum compatible with the angular spectrum of the temperature anisotropy of the cosmic microwave background (CMB)? The temperature anisotropy spectrum has a maximum around wavenumber $l \approx 200$ due to oscillations of the hot plasma before recombination. This range of the spectrum has recently been measured in Saskatoon¹⁰. We have calculated the angular spectrum for standard CDM-type model and a model with the peaked power spectrum⁹. This test shows that using an appropriate set of cosmological parameters the peaked power spectrum is in agreement with CMB data. However, CMB data is not sufficient to discriminate between the standard CDM-type and the peaked power spectrum.

A density field with a smooth power spectrum as produced in CDM-type models will generate a random distribution of high- and low-density regions⁷, in contrast to recent cluster data. This leads us to the conclusion that the combined evidence from cluster and CMB data favour models with a built-in scale in the *initial* spectrum. Double inflation models provide a possible scenario where the formation of a peak could have taken place. A version of the double inflation model is suggested by Starobinsky¹¹. The study of the distribution of matter on large scales could provide a direct test of more complicated models of inflation.

I thank H. Andernach, F. Atrio-Barandela, M. Einasto, S. Gottlöber, V. Müller, A. Starobinsky, E. Tago and D. Tucker for fruitful collaboration and permission to use our joint results in this talk. This study was supported by the Estonian Science Foundation.

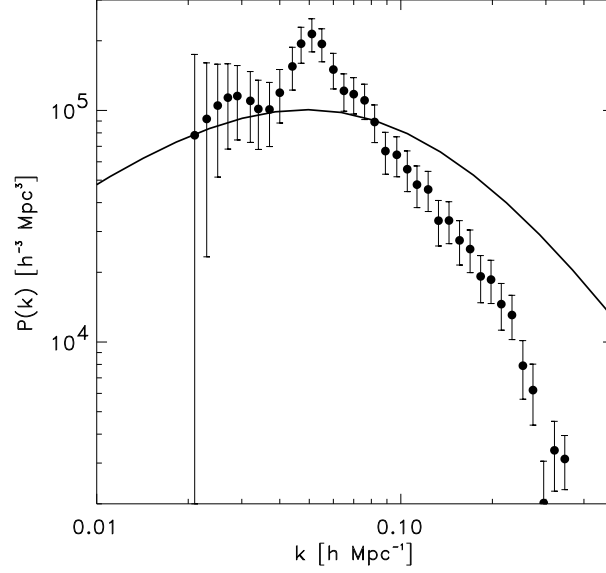


Figure 2: The power spectrum $P(k)$ for clusters with measured redshifts is plotted with solid circles; 2σ error bars are shown. The solid line is the standard CDM ($h = 0.5$, $\Omega = 1$) power spectrum enhanced by a bias factor of $b = 3$.

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